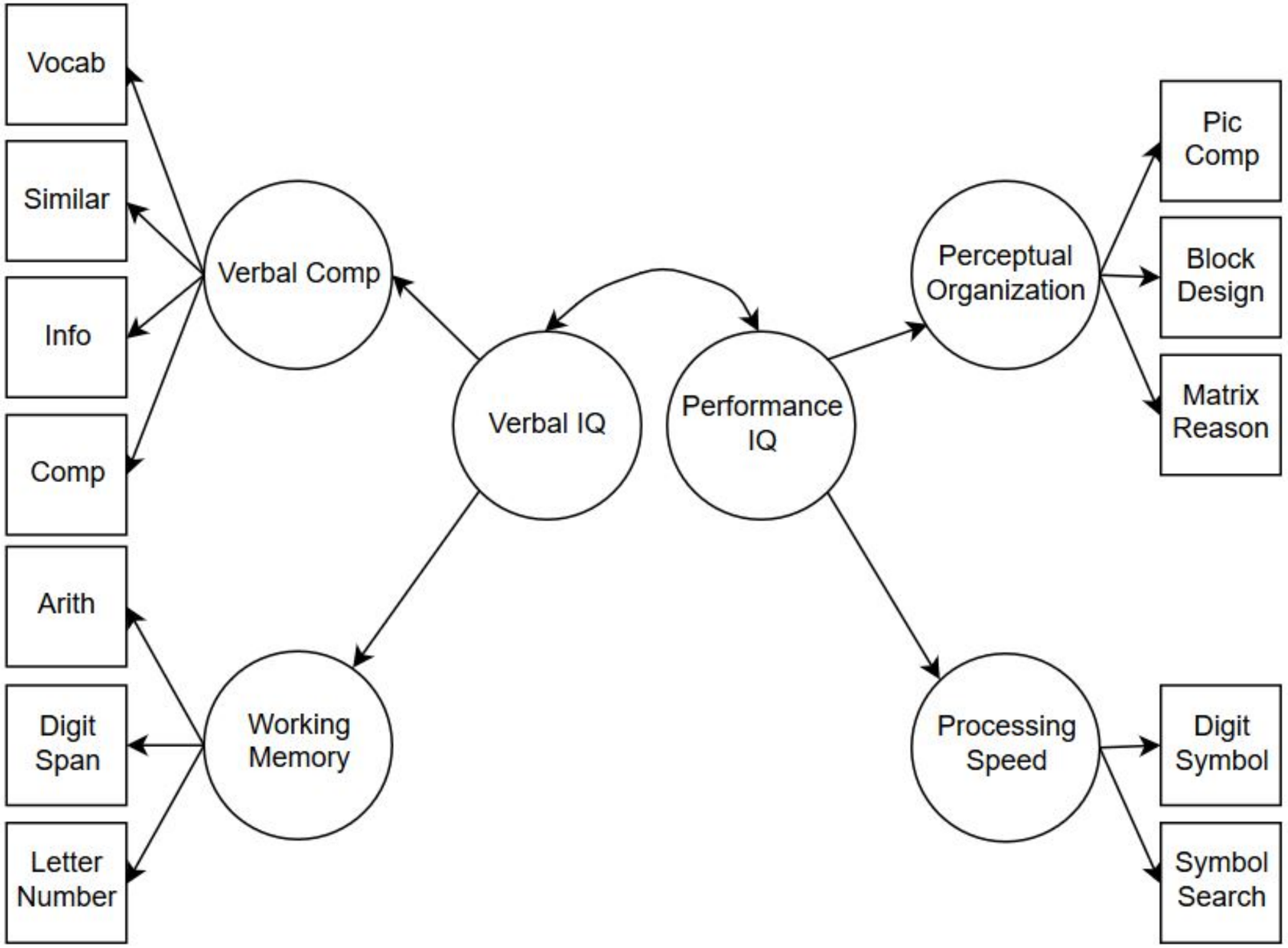
Model the WAIS-III IQ Scale

STRUCTURAL EQUATION MODELING WITH LAVAAN IN R

Erin Buchanan
Professor


Vocab
Similar
Info
Comp
Arith
Digit Span
Letter Number
Verbal Comp
Working Memory
Verbal IQ
Performance IQ
Perceptual Organization
Processing Speed
Pic Comp
Block Design
Matrix Reason
Digit Symbol
Symbol Search

WAIS-III Model

- The WAIS-III has four latent variables measured by 12 manifest variables.
- The model also includes a second layer of latent variables:
  - Verbal IQ predicts verbal comprehension and working memory.
  - Perceptual IQ predicts perceptual organization and processing speed.
- These factors are likely highly correlated.

How to Get Started

- Build the first level of latents.
  - Make sure the four factors of the WAIS-III run properly.
  - Check for Heywood cases and bad fit.
- Add the second level of latents.

Let's practice!

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Update the WAIS-III Model

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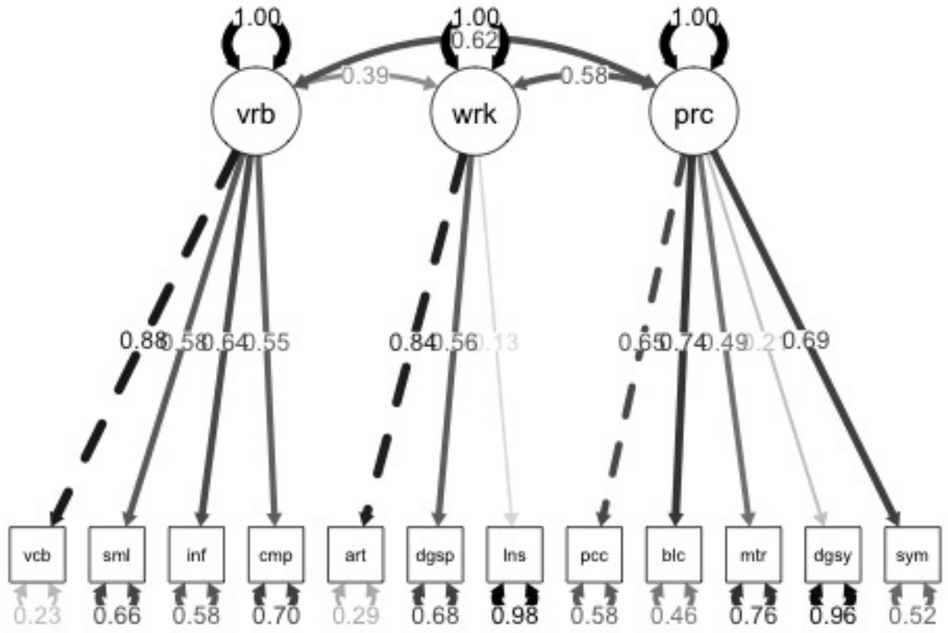
Three-Factor WAIS-III

```
semPaths(object = wais.fit, layout = "tree", rotation = 1,
         whatLabels = "std", edge.label.cex = 1,
         what = "std", edge.color = "black")
```



Factor Loadings

```
summary(wais.fit, standardized = TRUE, fit.measures = TRUE)
```

```
Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  verbalcomp =~
    vocab             1.000                               6.281    0.879
    simil             0.296    0.031    9.483    0.000    1.861    0.581
    inform            0.449    0.043   10.481    0.000    2.822    0.644
    compreh           0.315    0.035    8.999    0.000    1.981    0.552
  workingmemory =~
    arith             1.000                               2.528    0.844
    digspan           0.881    0.152    5.786    0.000    2.227    0.565
    lnseq             0.205    0.107    1.920    0.055    0.518    0.129
                                        - - -
```

Variances

```
Variances:
                 Estimate  Std.Err z-value P(>|z|)  Std.lv Std.all
                                    - - -
   .piccomp         3.138    0.317   9.913   0.000   3.138   0.577
   .block          27.343    3.226   8.476   0.000  27.343   0.459
   .matrixreason    4.960    0.441  11.243   0.000   4.960   0.757
   .digsym        132.291   10.925  12.109   0.000 132.291   0.957
                                    - - -
```

```
var(IQdata$digsym)
```

```
138.665
```

Fit Indices

```
User model versus baseline model:
  Comparative Fit Index (CFI)                    0.793
  Tucker-Lewis Index (TLI)                       0.733

Root Mean Square Error of Approximation:
  RMSEA                                          0.115
  90 Percent Confidence Interval          0.101  0.129
  P-value RMSEA <= 0.05                          0.000

Standardized Root Mean Square Residual:
  SRMR                                           0.076
```

Modification Indices

```
modificationindices(wais.fit, sort = TRUE)
              lhs op          rhs     mi     epc sepc.lv sepc.all s
66          simil ~~       inform 35.879  -3.757  -3.757   -0.268
56          vocab ~~       inform 28.377   9.783   9.783    0.313
48     perceptorg =~        vocab 21.865  -2.077  -3.151   -0.441
115         block ~~ matrixreason 16.209  -3.622  -3.622   -0.183
96          arith ~~        block 15.061   3.679   3.679    0.159
117         block ~~ symbolsearch 13.144   5.725   5.725    0.180
47  workingmemory =~ symbolsearch 12.272  -0.467  -1.181   -0.286
81         inform ~~        block 12.269   4.358   4.358    0.129
64          vocab ~~       digsym 11.578 -11.261 -11.261   -0.134
40  workingmemory =~        simil 11.383   0.278   0.703    0.220
72          simil ~~        block 10.605  -3.084  -3.084   -0.125
45  workingmemory =~ matrixreason  9.685   0.267   0.675    0.264
```

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A Hierarchical Model of IQ

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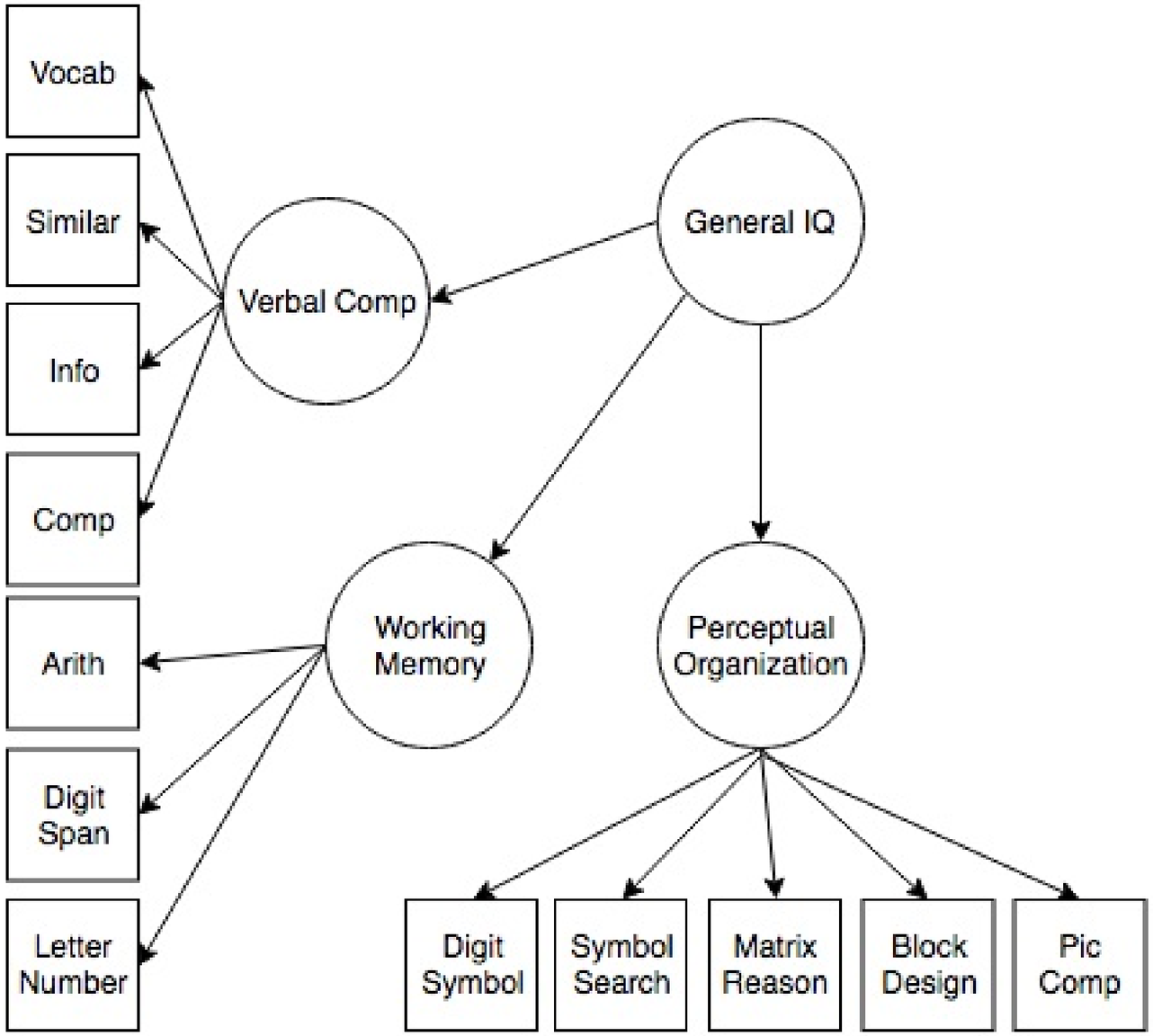
Vocab
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Arith
Digit Span
Letter Number
Verbal Comp
General IQ
Working Memory
Perceptual Organization
Digit Symbol
Symbol Search
Matrix Reason
Block Design
Pic Comp

Model Specification

```
#updated model with correlated error from exercise
wais.model2 <- 'verbalcomp =~ vocab + simil + inform + compreh
    workingmemory =~ arith + digspan + lnseq
    perceptorg =~ piccomp + block + matrixreason + digsym + symbolsearch
    simil ~~ inform'
```

```
#updated model with hierarchy added
wais.model3 <- 'verbalcomp =~ vocab + simil + inform + compreh
    workingmemory =~ arith + digspan + lnseq
    perceptorg =~ piccomp + block + matrixreason + digsym + symbolsearch
    simil ~~ inform
    general =~ verbalcomp + workingmemory + perceptorg'
```

No Change in Model Fit

```
#regular model
fitmeasures(wais.fit2, c("cfi", "tli"))
```

```
  cfi   tli
0.833 0.780
```

```
#hierarchical model
fitmeasures(wais.fit3, c("cfi", "tli"))
```

```
  cfi   tli
0.833 0.780
```

Why Use Hierarchical Models

```
Covariances:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  verbalcomp ~~
    workingmemory    6.278    1.181    5.315    0.000    0.416    0.416
    perceptorg       5.654    0.859    6.583    0.000    0.634    0.634
  workingmemory ~~
    perceptorg       2.237    0.363    6.172    0.000    0.576    0.576
```

```
  Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  general =~
    verbalcomp       1.000                               0.676    0.676
    workingmemory    0.396    0.060    6.635    0.000    0.615    0.615
    perceptorg       0.356    0.062    5.713    0.000    0.937    0.937
```

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Course Wrap Up

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What You've Learned

- Model Syntax
  - `=~` to define latent variables
  - `~~` to define covariance and correlation
  - `~` to define direct prediction
- Model Types
  - One-Factor Models
  - Multifactor Models
  - Hierarchical Models
- Data Visualization
  - `semPlot` library
  - Rotations, layout, and font sizes
  - Enhanced coloring

Congratulations!

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